AN EXPERIMENT IN AUTOMATIC DATA PROCESSING

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ABSTRACT

An experiment in the automatic preparation of input data for use in numerical prediction is described. The process includes the automatic recognition, identification, and decoding of the raw teletypewriter data up to the point where they are ready for use in objective analysis. The problems encountered and the methods used to attack these are described. Present methods of coding and communication are such as to impede progress in automatic processing of meteorological data. Suggestions are made for improved coding methods as well as for improvements in the methods of automatic processing used to date.

1. INTRODUCTION

From the first experiments in numerical weather prediction it became evident that the preparation of input data for the computation would be a major problem. The requirement for worldwide data dictates that widely varying sources must be used. The uncertainty of radio communication means that large masses of data containing many errors must be handled.

The initial approach to this problem consisted of hand conversion, plotting, and correction of the data (insofar as errors could be recognized). These data were then analyzed by hand so as to maintain vertical, horizontal, and time consistency. Final data were then read off from these analyzed charts into forms or directly punched, as read, into Hollerith-type cards.

The second approach to this problem consisted of taking the information from data observation points, organizing it manually, and punching it into cards for loading into the computer, an International Business Machine EDPM 701. The computer, either by a local least squares fitting [4] or by a successive adjustment of a first guess map [1], interpolates these data into information on a square grid suitable for numerical computations. Some evidence shows that this method produces superior starting data for numerical forecasting [4]. However, the hand preparation of data must be done under considerable pressure, and errors can easily get into the process in spite of methods of careful checking. There was not very much saving in personnel here, since keeping up with the teletypewriters on a three-level code on a small grid required a force of about six people during the rush period. In order to detect data errors it was necessary to plot the data simultaneously so that an analyst could estimate the credibility of each report.

This paper describes the latest experiment, in which the data are processed completely mechanically from the time of receipt as telegraph signals. The possibility of manual intervention is retained so that control is possible at each step of the process.

2. NATURE OF THE PROBLEM

Our present forecast models, as well as models of the foreseeable future, require input data which specify the wind and temperature fields with a rather large horizontal extent (in order to remove boundary errors to as great a distance as possible) and for a number of levels in the vertical. The exact number of levels in the vertical depends on the complexity of the models. In addition, precipitation forecasting would require a measure of moisture. Since the number of pressure surfaces that can reasonably be used in the vertical depends upon the horizontal coverage of the data, as discussed by Fjørtoft [2], Thompson [8], and others, a rather limited number of pressure surfaces defines the atmosphere to the refinement that can be reasonably used in large-scale forecasting. This means that at present the required data for numerical forecasting must be extracted from a vast amount of data that is not to be used. The usable part of the upper air data is at most only about one part in ten, at least for large-scale forecasting requirements. The remaining nine-tenths of the data are useful mainly for checking the accuracy of transmission of the one-tenth, by means of the hydrostatic relationship and by vertical consistency considerations. Better organization of the transmitting codes could provide for a proportionate reduction in the volume of data to be handled and also could provide for more direct and simpler checking for accuracy. A sample effort in this direction was proposed by Gilchrist and Cressman [3].

When the meteorological codes are considered for automatic handling, the following main difficulties occur:

(a) there is no simple positive identification of the start and finish of each message,

(b) the type of message is not clearly indicated,

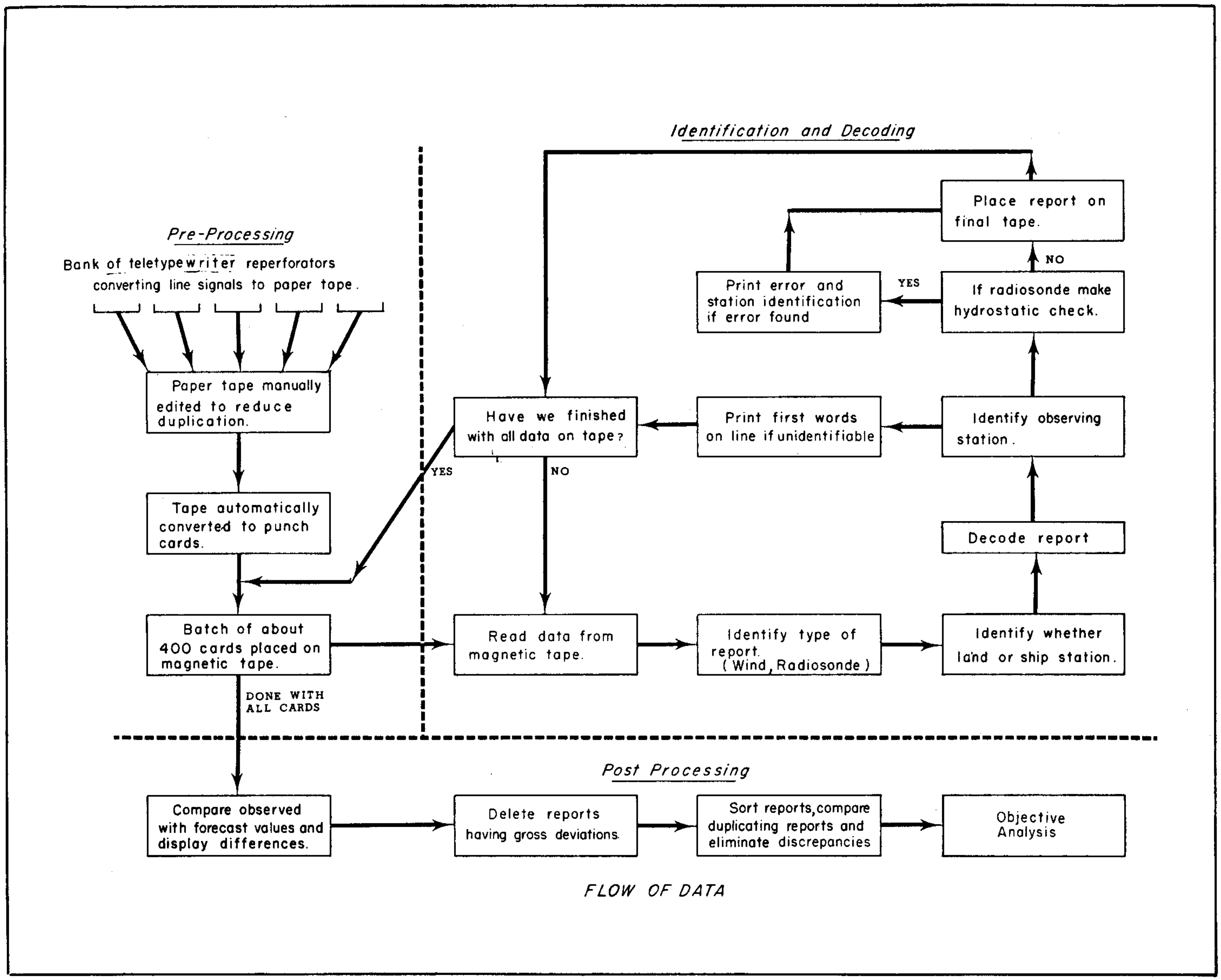

FIGURE 1.—The general flow in the operation of the automatic data processing program.

(c) an unnecessary number of local variations of code form is permitted,
(d) the station that took the observation can be identified in one of a number of forms,
(e) some of the station identifications, such as three decimal digit index numbers, are ambiguous if the headings are lost, and
(f) a large proportion of the message headings is lost or garbled.

3. DESIGN OF THE AUTOMATIC PROCESSING PROGRAM

The complete process of automatic data processing (ADP) is shown schematically in the flow chart, figure 1. The first two preprocessing items are done externally to the computer, as the data are being received. In order to receive complete upper-air coverage it is necessary to monitor about ten teletypewriter channels, thus contending with a great amount of duplication. Editing of the raw teletypewriter data is necessary to make the data manageable. Since the computer used here is designed for loading with punched cards, the teletypewriter tape is first converted automatically to cards, one card per teletypewriter line. This also makes possible the insertion of controlling cards to replace missing or badly garbled headings or other identification information. Since the present computer reads cards at 150 cards per minute and about 2,500 cards are required for Northern Hemisphere data, an appreciable amount of time in the program is required for loading. However, the problem does not quite justify the cost of off-line magnetic tape loading equipment. Figure 2 shows the equipment used in the generation of teletypewriter tape and the conversion from tape to cards. It was necessary to add more teletypewriter circuits (and reperforators) after this picture was taken.

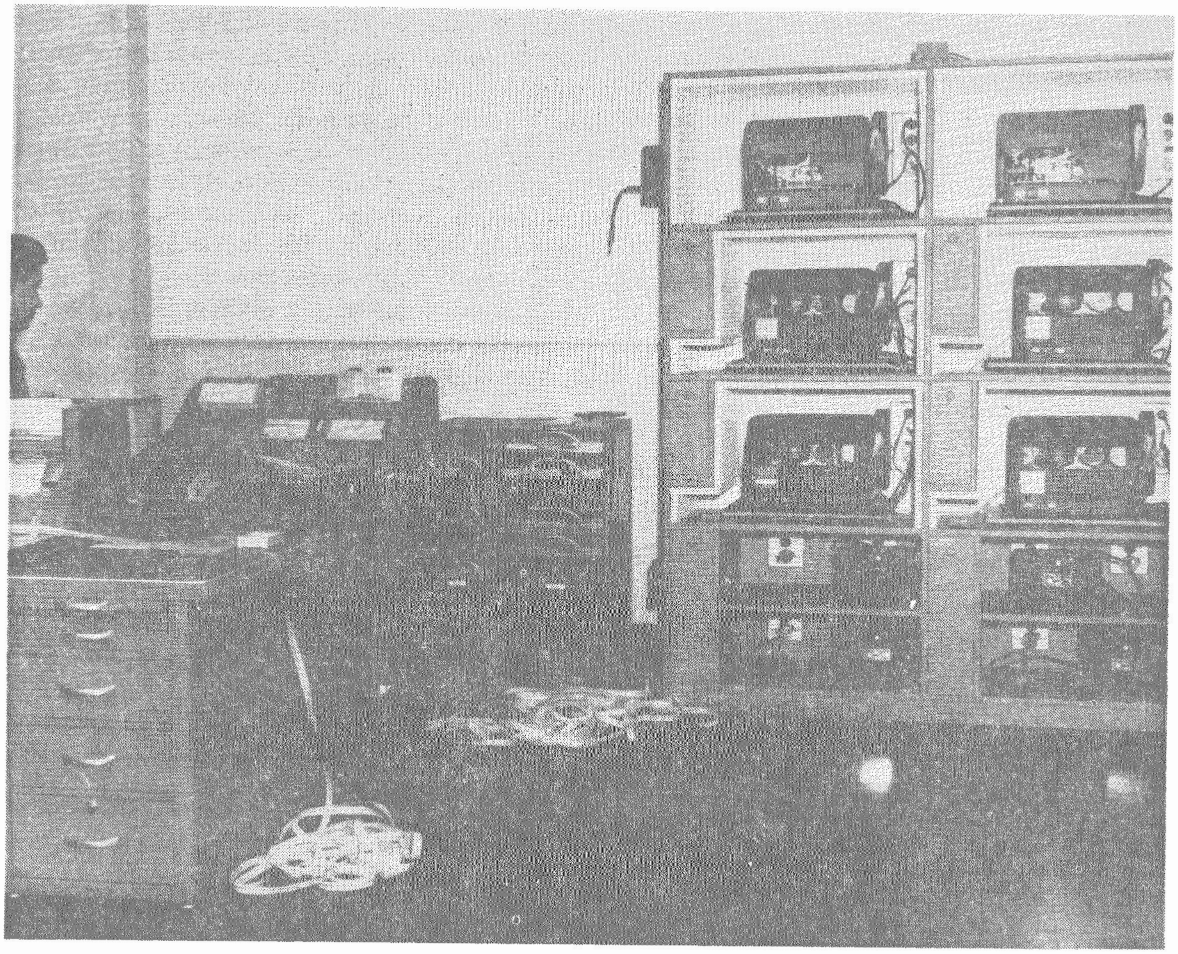

FIGURE 2.—Teletypewriter reperforators and tape-to-card converters in operation.

The design of the program is somewhat arbitrary and represents an attempt to see what can be done with a minimum of effort. First, it was decided that some control should be kept of the bulletin headings. Possible index numbers should be sought only in a limited list. The message headings are among the most carelessly prepared and most often deleted information on the circuits. It is therefore necessary to insert cards punched as pseudo-headings to mark places where the data change from one area to another without proper indication. A message heading ordinarily should contain a seven-digit word, the date-time group. The administration program therefore divides the lines into blocks each headed by a line containing a word greater than five digits. Each time more data are required, one of these blocks is read and the first line is examined to see if it is a message heading. If it is not, the long word is divided as if it were composed of accidentally run-together words.

There is provided a dictionary of stations consisting of a list of all the upper-air stations together with their call letters, if any, their index numbers, and their geographical locations. The dictionary is divided into three major parts. Part I contains the call letters of the fixed ships together with the units in which they report. Part II contains all of the stations which may have to be recognized by three-digit index numbers or by call letters. Stations in the area can also be recognized by five-digit index numbers, if under the proper heading. Part II is subdivided into sixteen parts. This reduces the searching time for finding something within an area, and partitions all of the duplicate index numbers such that if the area is identified correctly each three-digit number is unique. Part III contains all of the stations which may be looked up by five-digit index numbers regardless of message heading. They are confined to Europe, Africa, and Asia.

As each heading is recognized, the appropriate area in Part II is designated. The only search outside this preselected area that is permitted is in the case of two- and three-digit call letters. If one of these is found the dictionary control is shifted to the appropriate area.

One of the reasons for this strict control is that numerical identifiers are not unique and can easily be confused with data. There are many upper-air stations with common three-digit index numbers. Five-digit numbers can be confused with data groups or with three-digit index numbers having an illegal time group. As a result of this strict control, stations that make unusual deviations from the codes are printed immediately for attention instead of being mislocated.

The internal part of the program is divided into two parts, decoding and locating of the station. The first stage of decoding is the identification of the code type and the location of the start of the report. Each line that could potentially begin a message is examined far enough to determine that it definitely does or does not. If it passes the preliminary tests it has been determined to be an international upper wind report, a United States upper wind report, a ship upper wind report, or a radiosonde report. Also at this point the most likely word for the location identification has been determined. The search for the location identification starts from the message and works back toward the beginning of the line. Due to the automatic station identification system on some circuits, a station that transmits another station's message produces a double identification, the one closer to the message being the correct one.

4. DETECTION OF THE METEOROLOGICAL DATA

The preliminary tests consist of first examining a line for either a five- and four-digit word alternation (United States upper wind) or a sequential first-digit series in a line of five-digit words (international or ship upper wind). If these tests fail, and the line is composed mostly of five-digit words, the radiosonde tests begin. Here, we have a serious difficulty. The digits used to identify the mandatory pressure surfaces and which give a characteristic form to the radiosonde message are mostly ambiguous. That is, the same digits in similar locations in the data words can also indicate temperatures. No difficulty arises as long as there are the same number of words for each pressure surface. This is recognized in the approved code form by a rule we can refer to as the "spacing rule" [9]. Unfortunately not all countries pay attention to this with the result that ambiguities can arise in internationally exchanged upper-air data. Garbles also give a similar result. An additional problem arises from the fact that internationally exchanged reports do not have similar content. Some countries do not transmit 400-mb. data, while others transmit 600-mb. data. Also, the 1,000-mb. and 850-mb. temperature and wind groups may or may not be reported, depending on station elevation. The solution adopted was to scan the message in a forward direction for a group starting with either "40" or "30", the lowest unambiguous pressure surface indicators. If the group "55555", meaning end of part I of the sounding, is encountered first (as in dropsonde reports) a radiosonde

TABLE 1a.—*Code forms*

Code	Recognition Features	Difficulties
U. S. upper wind code	Alternation of 4- and 5-digit groups to 10,000 ft., 5-digit groups thereafter. The 5-digit groups are in a sequence 2, 4, 6, etc., starting with the elevation of the station.	Accidental 4-digit words occur elsewhere causing false starts.
International upper wind code	5-digit code in sequence 1, 2, 3, 4, 5, etc., starting with the elevation of the station. Each 10,000 foot level is headed by 9999X where X is the 10,000's unit.	Sequences of numbers sometimes occur randomly in the data.
Ship upper wind code	5-digit code similar to the above except that it contains two 5-digit groups containing the latitude and longitude.	Ship messages are very poorly identified. Sometimes they contain the word "ship," sometimes they have ship identifications, and sometimes the name of the ship. Since the locations of the ships are not known a priori they can be badly mislocated due to errors.
PISEL	An abbreviated wind message originating mostly in Europe containing only the standard levels.	Not used in the present procedure as most of the significant winds are repeated in the radiosonde message.
Radiosonde:		
1. Land Station without wind	Sequence 85, 70, 50, 40, or 85, 70, 60, 50, 40 occurs, in every other word. Ends in 55555. May not be a 40 but may have 30, 20.	All of the level identifiers except 40 can occur as possible temperatures.
2. Land station with wind	Sequence 85, 70, 50, 40, or 85, 70, 60, 50, 40 occurs in every third word. Ends in 55555. May not be a 40 but may have 30, 20.	Stations frequently mix these two codes—transmitting 3 groups per level to the end of the wind, then transmitting 2 groups per level.
3. Ship station with or without wind	Sequence as above except that the 1,000-mb. height is preceded by 00 instead of the time and there are at least two additional groups before the 1,000.	Ships are often poorly identified.
4. Mesran	Same as above except the extra information about significant points does not follow.	Due to the fact that the 1,000-mb. group is usually not complete and the 850 may not be complete, as well as the presence of unnecessary words, the location of the 70 indicator may vary from the 3d to the 10th word in line.
5. Dropsonde	Contains a group 71717 after the latitude-longitude groups and terminates at 50. Otherwise conforms to ship code.	
6. ABTOP	A very neat selected-level code with information in two groups per level. Has rigid spacing rules so that any level can be identified.	Code form must be identified by the word "ABTOP" in the heading.

TABLE 1b.—*Set of rules for distinguishing code forms*

I. Start with the first 5-digit number after the first word in the line.
  a. If one of the following 3 words is a 4-digit word, test for U. S. Pibal Code.
  b. If the following 3 words are 5-digit and the data originated from a ship,
    (1) If the third following word begins with 2 and the fourth following with 3, assume it is a ship pibal.
    (2) If not above enter the test for a raob (d).
  c. If the following word is 5-digit and the data originated from a land station,
    (1) If second following word has a first digit one greater than that of the first following word assume it is a land pibal.
    (2) If not above enter the test for a raob (d)
  d. If the following word is 5-digit and does not meet criterion b or c search 17 groups for the following in order of priority:
    (1) a 5-digit word starting 40,
    (2) a 5-digit word starting 30,
    (3) a 5-digit word 55555.

II. If any of the above are found examine the previous word, if it:
  a. Starts with zero, the third previous a 50, and the sixth previous either 60 or 70, then it is a raob with winds.
  b. Does not start with a zero, but the second previous starts with 50 and the fourth previous 60 or 70, then it is a raob without winds.

report is also recognized. If none of the above can be located within the possible number of words, the data are discarded as "junk" (irrelevant) and the next line is considered. If a radiosonde report is thus tentatively recognized, the report is scanned backwards until enough form is established for extraction of the relevant data.

The threshold at which sufficient form is established for recognition of a report can be set at any arbitrary level. It appears impossible to avoid completely the recognition of random numbers as data unless considerable form is demanded. On the other hand, a high threshold requirement for form means that some partially garbled but partially useful material is rejected.

A recent paper by Glantz [5] gives some striking illustrations of this difficulty. It can be seen that the problem of automatic processing of meteorological data is in many ways similar to that of automatic language translation [6].

Table 1a shows the principal features of the program in use. Table 1b shows a set of rules which is used to determine the code form, applicable to all of the codes except PISEL* and ABTOP*. At present PISEL is ignored because most of the winds outside of the United States also come with the radiosonde reports. ABTOP is identified by the word ABTOP at the head of the message, which brings a special program into play.

*PISEL=Abbreviated upper wind code for standard pressure levels.
ABTOP=Report of geopotential, temperature, humidity, and wind at standard pressure levels.
Both originate mainly in Europe.

At this point a comment is in order about the simplicity of the ABTOP Code. This code has a rigid form making group identification unnecessary. Extra groups have been eliminated at the beginning of the message, the groups for each level forming a vertical column down the page. Errors due to garbling are controlled by the hydrostatic check.

Table 2a shows the principal location identifications that must be dealt with. Table 2b shows the rules for determining which word is to be looked up as the identifier for locations in North America, the Atlantic, and the Pacific. In Europe, Asia, and Africa a different set of rules is used, since five-digit identifiers are used almost universally.

In the second part of the decoding section the information for the standard levels is actually extracted. In the case of radiosondes a hydrostatic check is performed, checking data preparation errors as well as miscoding and communication errors. Winds could be checked for consistency with the levels above and below, but in this code they are required only to be consistent between the pilot balloon report and the radiosonde report. The main problems in this section are the problem caused by missing wind groups and the estimation of the missing first digit of heights in a report transmitted in whole meters.

At first, units were controlled by bulletin heading. Later as stations in the Pacific and Greenland changed to meters, each station had to be recorded individually in the

TABLE 2a.—*Station identification types*

Station identification	Source	Difficulties
4-letter calls	ICAO identifiers and ships	Hard to separate from accidental 4 letters produced by 3-letter call errors.
3-letter calls	U. S. reports and ocean stations	May be multiple identification as when one station transmits another message. A false digit is sometimes added making a 4-digit call. Ocean stations frequently are spread out into 3 one-digit words and the identification may be on the previous line.
2-letter calls	Canada	Same as above, neither of these can be mistaken for a data word. Sometimes false two-digit calls originate when radio operator's initials precede a report.
3-number index	U. S. reports and in some countries on their private collections. May be relayed this way.	Very dangerous if separated from message headings because there are many duplicate index numbers in different blocks. Also some stations include a time indicator with the 3-digit identifier which makes it look like a 5-digit identifier.
5-number index	Most international relays	Easily confused with 5-digit data words. Certain countries place the 5-digit identifier on the previous line. Some prefix 999 bl. It is not located uniformly.
Ships	All types of bulletins	Since their location is not known in advance coding errors can easily cause them to be mislocated.

TABLE 2b.—*Set of rules for identifying stations*

Indexing Rules for North America and Pacific including Japan
I. Start with the word before the first 5-digit number on the line after the first word on the line.
II. If the word under consideration is not the first word on the line and it is: (a) 5-digit word—back up on the line one more word. (b) 4-digit word—test to see if it is the word "Ship", otherwise back up one word. (c) 3-digit word containing letters—look it up in the list of call letters. (d) 3-digit word containing all numbers—look it up in the list of index numbers for the dictionary subsection. (e) 2-digit word containing letters—look it up in the list of call letters. (f) any other word—back up one.
III. If the word under consideration is the first word in the line and it is one of the following, Temp, Pilot, US, or UC, apply these rules to the second word, otherwise apply them to the first: (a) 5-digit call letters—unidentifiable. (b) 5-digit, first two are letters—look up the index numbers as 3-digit index numbers in the list for the dictionary subsection. (c) 5-digit, first three are letters—look up the letters in the call letters. (d) 4-digit, all numbers—unidentifiable. 4-digit, first letter "N"—try to decode as a ship message. 4-digit, other—delete the first letter and try to find the last three in the call letters. If not found then try as a ship. (e) 3-digit word containing letters—look it up in the list of call letters. (f) 3-digit word containing all numbers—look it up in the list of numbers for the dictionary subsection. (g) 2-digit word containing letters—look it up in the list of call letters. (h) 2-digit word containing numbers—unidentifiable. (i) Any one digit—unidentifiable.

449189—57——2

dictionary as to whether the report was in meters or feet. Also Russian stations, which had been reporting in decameters changed to meters, which helped conformity; but at the same time their winds are transmitted in meters per second.

5. IDENTIFICATION OF THE REPORTING STATION

The second part of the origin identification consists of actually looking up the station in the dictionary. Since the dictionary is by nature large it is kept on the magnetic drum in the computer. Looking up an entry is therefore somewhat slow, and is postponed until the last possible moment. Since alphabetic call letters are more nearly unique they are looked up whenever encountered. This is desirable particularly for ships. In case no entry can be found in the dictionary for a call letter or index number, a display is printed of the information on the line through the first five-digit number, together with reference information, which makes it possible to determine why the station was rejected, and the number of the original data card. This display is shown in figure 3. If the rejection is due to bad message headings the rejected cards can be put in another load together with the proper message heading and recovered. This display is very useful in monitoring for changes. For instance, when the Idlewild radiosonde started transmitting with the same three-digit index number as Ely it was discovered immediately. Likewise, when the Japanese converted their units to meters without a warning being received at the operating levels an outbreak of hydrostatic checks caused us to discover this without delay.

```
1   9 248   5 125      THIS NOT FOUND //8/2 62710


1  23  23  16  58      THIS NOT FOUND 61401 14082
2  23  57  16 300      THIS NOT FOUND 03946 14140
3 127 130  08 495   HYDROSTATIC CHECK                850 - 700 MB
4 148 148 +58  29   HYDROSTATIC CHECK                850 - 700 MB
5 178 178  10  67      THIS NOT FOUND 15653 15990
6 189 290   7 401      THIS NOT FOUND OTE 15970
7 189 306   7  67      THIS NOT FOUND AKN15 94  2104 21705


1   1  95   4 401      THIS NOT FOUND GGW COR US768 15513
2 149 149  72 202   HYDROSTATIC CHECK                850 - 700 MB
3 168 180  72 938   HYDROSTATIC CHECK                850 - 700 MB
4 293 293  72 240   HYDROSTATIC CHECK     LCH       1000 - 850 MB
5 326 327  72 280   HYDROSTATIC CHECK                850 - 700 MB


1   1   1  16 300      THIS NOT FOUND 13660 01814
2 212 212   8 215      THIS NOT FOUND NSYF 21303
3 212 212 +52  35   HYDROSTATIC CHECK                850 - 700 MB
4 253 253 +62  33   HYDROSTATIC CHECK               1000 - 850 MB
5 253 253 +62  33   HYDROSTATIC CHECK                850 - 700 MB
6 253 253 +62  33   HYDROSTATIC CHECK                500 - 400 MB


7 372 383   1 125      THIS NOT FOUND SALIN AS 10268
1  47  47  72 906   HYDROSTATIC CHECK               1000 - 850 MB
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FIGURE 3.—An example of the rejection sheet on March 10, 1957. On each line from left to right is the following:

Column one, the number of the rejection within one load (the loads consisted of maximum of 400 cards to minimize the time required for recovery);

Column two, a card reference number for the last card identified as a message heading;

Column three, a card reference number for the last card that should have been a message number (these two references made possible the location of the report in the original data);

Column four, a number telling the dictionary area from 1 to 16 in which the code was searching, or in the case of hydrostatic checks it contains the block number of land stations or a "+" sign and the latitude of a ship station;

Column five contains a clue as to why the station was not found or, if a hydrostatic check, contains the index number of a land station or the longitude of a ship station; after the identification of the line is printed exactly what was not found or what levels failed to check.

Note that in this list only one failure occured at 500 mb.

6. POST-PROCESSING

After the information has been properly extracted, checked, and stored away, and the cycle has been repeated until all of the information has been treated, the end product is a magnetic tape which contains edited data. It still has much duplication, the data being in the order in which they were received. Large errors can still be in the data; for instance, a partially garbled report containing only 500-mb. data which makes a hydrostatic check impossible, or a ship reporting in the wrong octant of the globe, either of which might be accepted as good data. To control this a rapid pass through the data is made to compare each observation with the 12-hour forecast made from the previous observations. A visual display is made of the worst piece of data in each grid square. The data worse than some criterion are automatically deleted. Any piece of data can be eliminated at the discretion of the analyst. Unfortunately in the Pacific and near the western boundary of the forecast grid rather large forecast errors can occur even in the 12-hour forecast. A criterion of a deviation of 600 ft. or a 50-kt. vector error of the wind was set as the rejection point of the data. This automatically removes the worst data and if it does on occasion throw out a valid report provisions are made to reinsert these reports at the discretion of an analyst. The data are then sorted into geographical order, duplicate information is checked and deleted, and the material is ready for analysis.

7. GENERAL EFFICIENCY OF THE SYSTEM

This system has been in operation on a test basis for nearly a year. With practice the pre-operations can be carried on by one person and the monitoring and correction can be done by one analyst, who also supervises the preparation of control information.

The operation of this code on the 701 computer is of marginal benefit. Due to the novelty of the operation and the lack of organization of meteorological data in general, the complete automatic system has been used only for 500-mb. data, although the output of the ADP program includes all the levels from 1,000 mb. to 400 mb. Considerable time is consumed because of the slow card-reading speed of the 701, which uses about half of the total running time. The large look-up tables had to be placed in the intermediate speed memory system, slowing the operation of the code considerably.

The whole process of handling a day's input cards requires about 40 minutes of computer time. On the new IBM 704 computer for the JNWP Unit this situation will be greatly improved. A higher speed card-reader will be available. Larger memory capacity will make it possible to keep the look-up tables more readily available, and experience derived from this first program will provide a program with a basically more efficient design. A further increase in overall efficiency will result from the eventual use of data from several levels instead of just one.

8. METEOROLOGICAL COMMUNICATIONS FOR AUTOMATIC DATA PROCESSING

A word should be said at this point about the experience this has given concerning the meteorological communications system. Traditionally meteorologists have added more and more communications onto an already overburdened system on the theory that the more information you have the better off you are. The communicators' solution to their problem has been to increase the speed of data transmission and to add more circuits bringing more and more information into centers. Manual editing of data to provide better selection at relay points is not a completely satisfactory solution because editors rehandling masses of data are responsible for many errors.

A proposed solution for this problem would be to make two types of collections on the originating circuits. One collection would be a standard-level type of abbreviated code, with very high priority, for worldwide dissemination. A model of this type of bulletin is the European ABTOP code originating from Frankfurt, which has a very high density of usable information. The second collection could contain significant point information and detailed wind information in the vertical (which loses interest the farther away it is transmitted) primarily for local distribution. This procedure could give the following benefits: (a) it could reduce the volume of data to be transmitted and could expedite the transmission of data at no increase in cost, (b) it could provide makeup time on the circuits allowing repetition of high priority bulletins if transmission conditions are poor, and (c) it could justify the use of a high-cost channel such as ocean cable to insure prompt data receipt.

A second problem for data processing is the handling of nonstandardized information. This is mainly a problem for the oceans, since data over most land areas seem quite adequate for large-scale analysis. Ship reports are very important for analysis, but frequently contain wrong positions or are otherwise mishandled, arriving in damaged form. This is partly due to the fact that they may be relayed through nonmeteorological channels to the weather circuits. Surface reports from merchant ships are notably so full of errors that it is necessary to keep logs on ships to rate their credibility. Reports from commercial aircraft are very useful on the Atlantic and vital on the Pacific, but are mixed in abbreviated plain language and the old POMAR code, and are nearly unreadable to plotters, to say nothing of the difficulties of preparing a machine code to handle them. One thing that is often overlooked in the resort to plain language is that meteorological reports are an international commodity and any comment in a noncoded form may be wasted when it gets into another language area.

A third problem involving communication is the present haphazard system of transmitting corrections when the sender has detected an error. Frequently in international communication these involve comments in French, English, etc., such as "first word third line should read." Proper codes should be provided for making these statements.

Finally, more conformity with the existing codes ought to be required by all participating countries. Numerous examples could be shown of the following defects: adding time groups to three-digit index numbers to produce five-digit numbers of which the first three rather than the last are the index; placing the identification on the previous line; splitting ship call signs into three one-digit words; unauthorized and unnecessary plain language such as "Temp Ships 4xx Raob First"; violation of the spacing rule for radiosonde reports; and many others. All of these deviations require special testing to prevent failures.

9. CONCLUSIONS

In summary, the first experience in automatic meteorological data processing shows that it can be accomplished, but that some desirable changes in the organization of the data could make the process much more efficient. Meteorological codes and communication practices were originally designed for manual operations and for a wide variety of uses. The advent of automatic data processing increases the need for greater specialization of communications and for greater regularity of procedure.

The availability of more advanced computing equipment together with the experience gained in the system described above will result in a considerably improved automatic data processing system within the next year. It is possible that by this time the results of automatic processing can be made available to others in addition to the processing unit itself in the form of concise, well-organized, and accurate bulletins.

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